Assessing the Cost-Effective Energy Saving Potential from Top-10 Appliances in India

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9th International Conference on
Energy Efficiency in Domestic Appliances and Lighting (EEDAL)
September 13-15, 2017
University of California, Irvine

Motivation

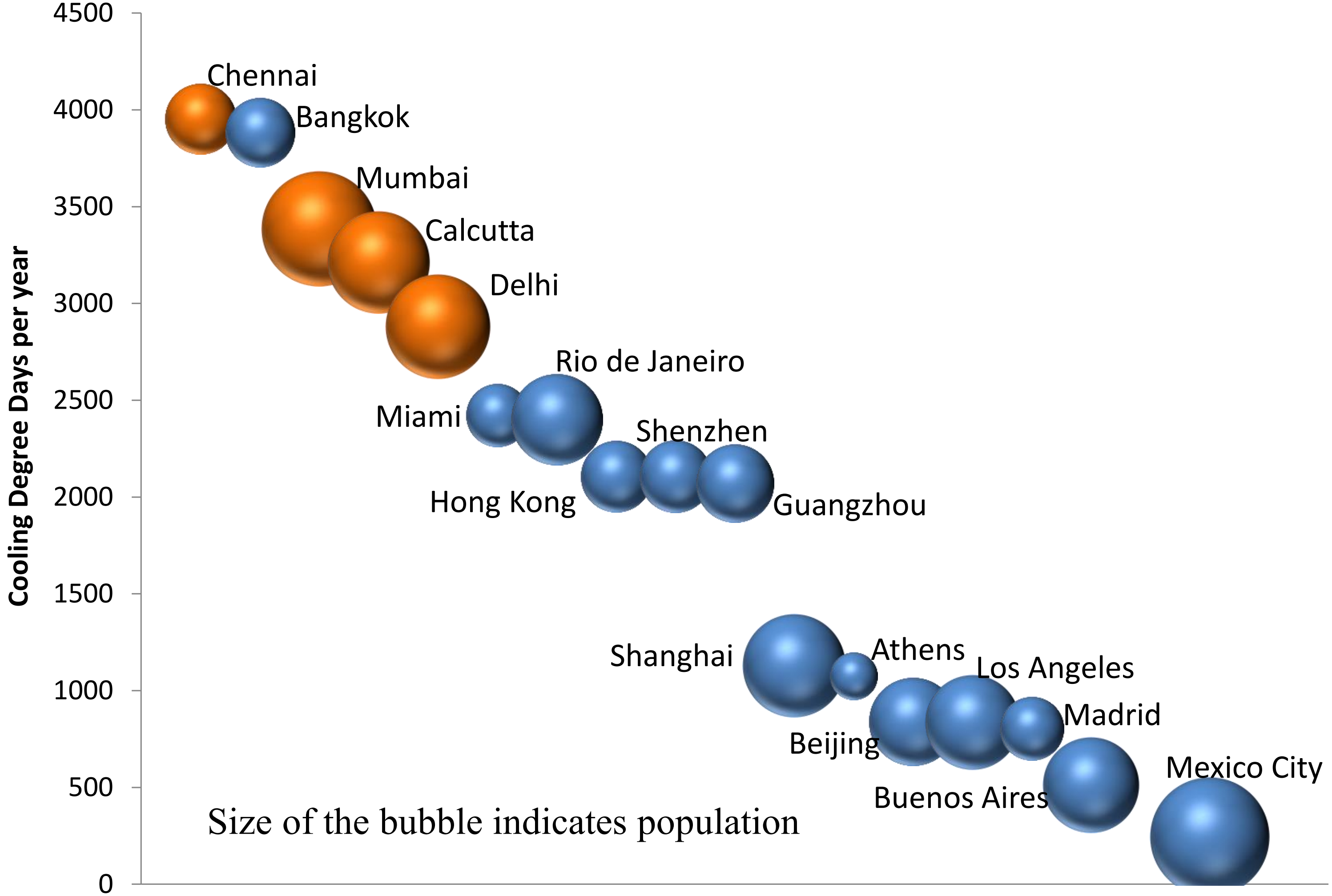
- Top-10 electrical appliances consume nearly 70% of the electricity in the country
  - Lighting, fans, room ACs, refrigerators, TV, motors, distribution transformers, water heaters, and Agricultural (Ag) pumps

- Given the technology improvements and deep reduction in the cost of efficient components, significant efficiency enhancement is possible cost-effectively by switching to super-efficient products

- Our objective is to assess the total energy and peak load saving if the entire cost-effective potential existing today (2016) is fully captured by 2030.
  - i.e. by 2030, stock average energy efficiency reaches 2016's cost-effective super-efficiency levels (very conservative)

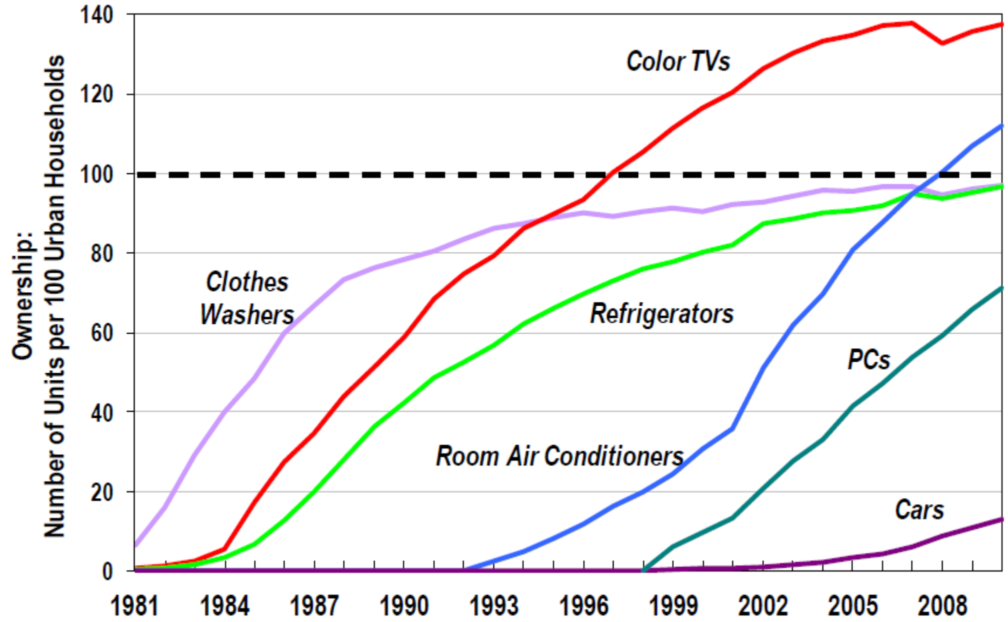
Indian cities are hot and populous

Compared to other regions, climate in India has higher cooling requirements



Data source: Sivak (2009)

Room AC demand: Huge Increase Expected by 2030-2040



Appliance Penetration in Urban China

Source: Zhou et al (2012)

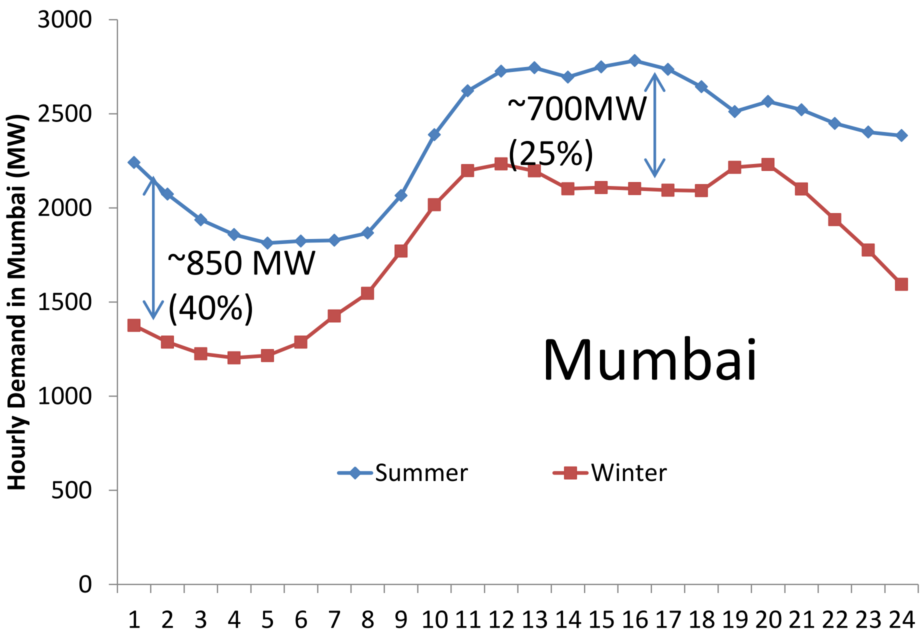
In India, room AC sales are growing at 10-15% per yr

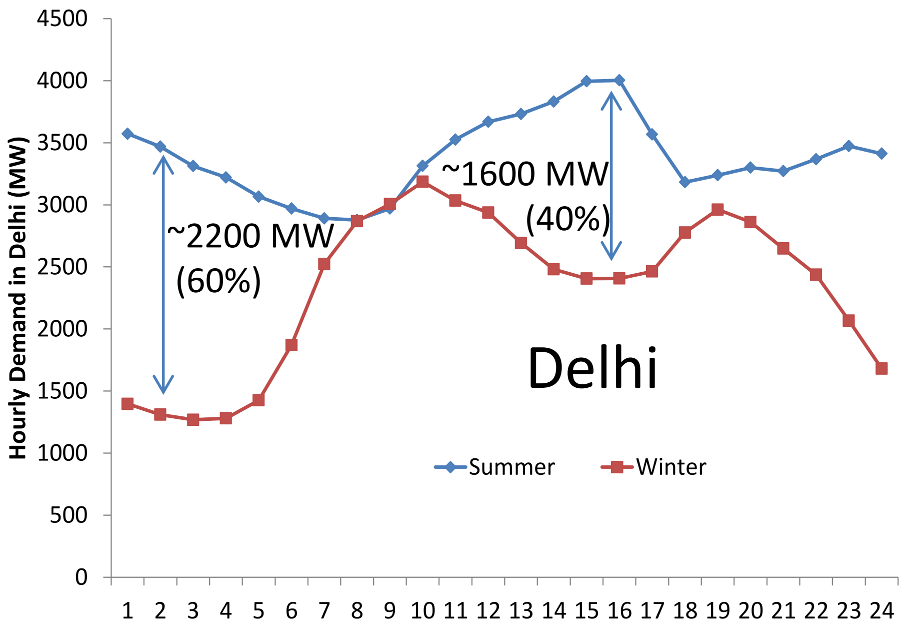
Room AC prices (real) have fallen by 40% in the last decade

Current Room AC penetration is ~ 5%; could increase to >70% in ~20 years

Load shape in Indian cities is already changing

Load Curves on a Summer and Winter Day (Average) in Mumbai and Delhi





Methodology

- We create two scenarios:

  – ***Business as Usual (BAU)***:

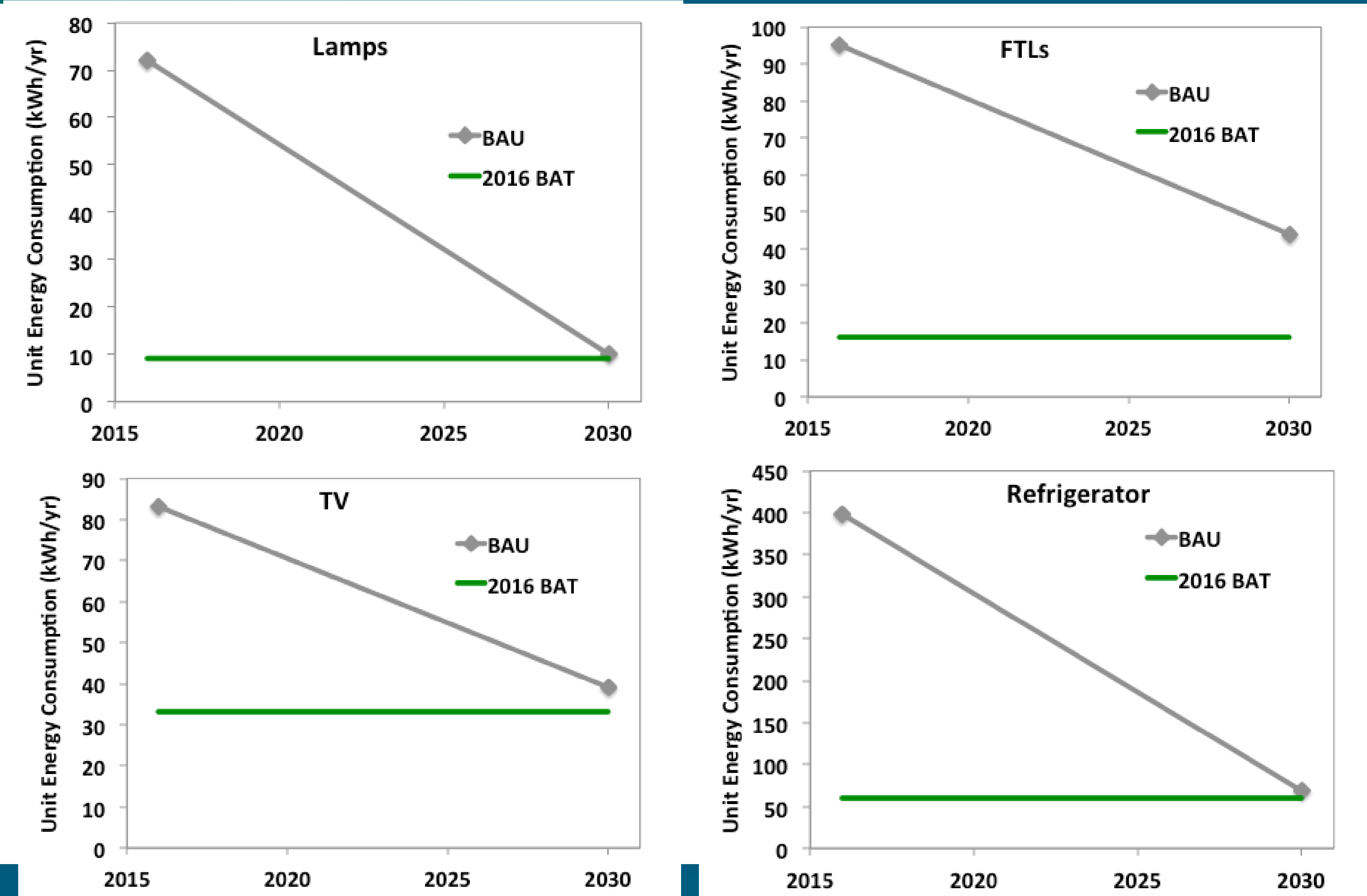
    Appliance efficiency improves between 2016 and 2030 per the historical trajectory

  – ***Efficient Future***:

    All new appliance sales between 2016 and 2030 are replaced by the current (2016) globally best available technology (BAT)

- We use BUENAS model to project the future appliance sales and stock

Current status of appliance efficiency, expected improvements, and globally best available technology



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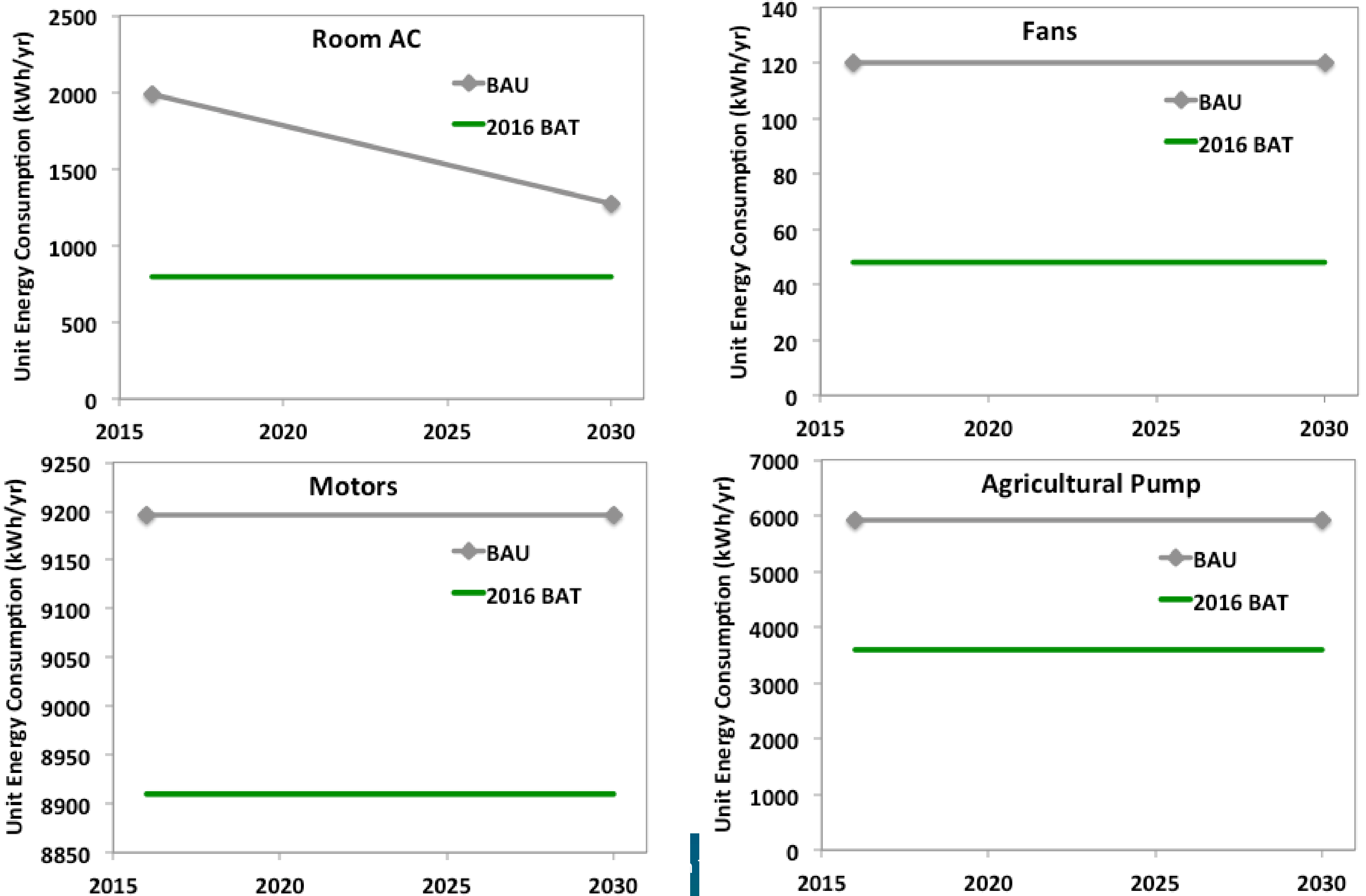
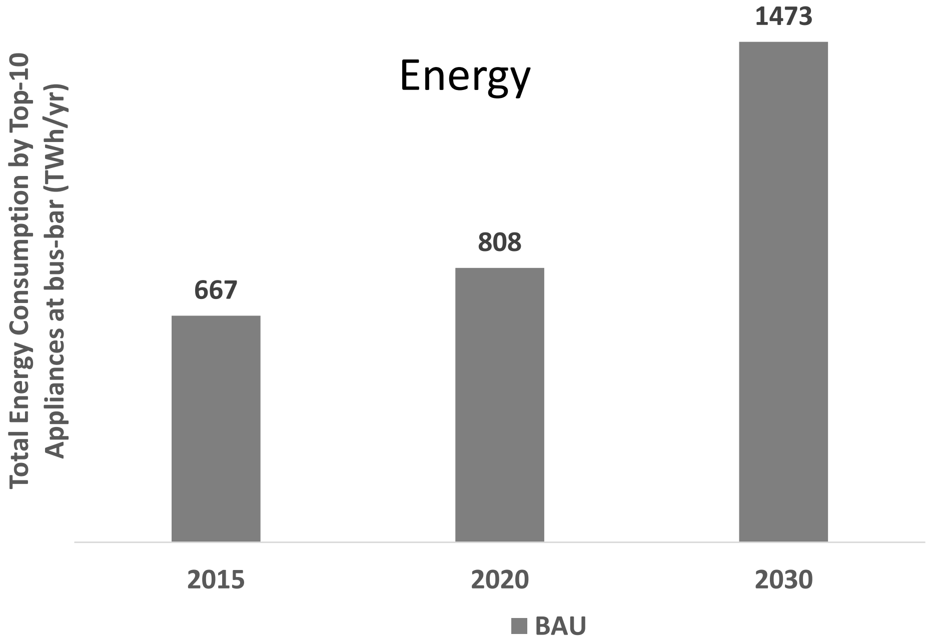
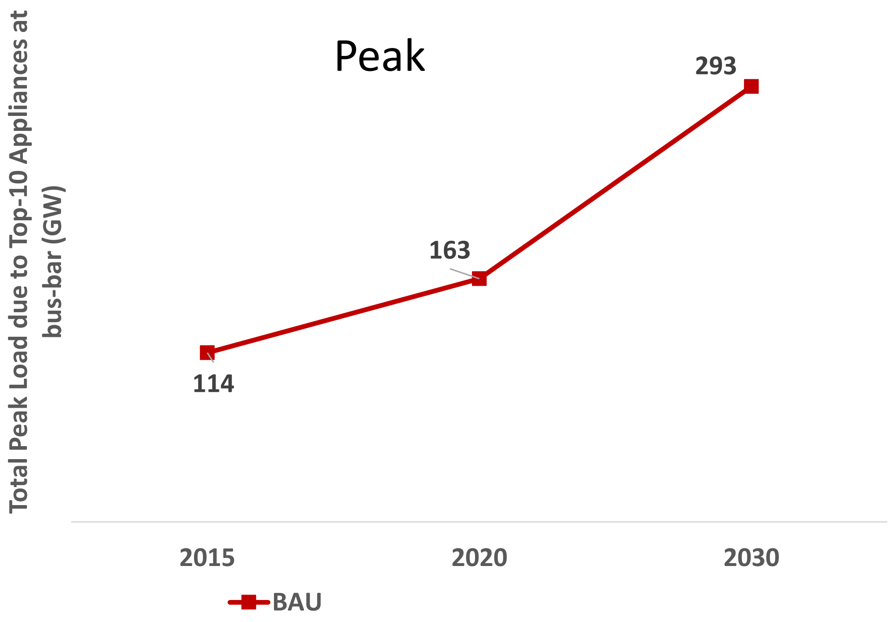


Key Results

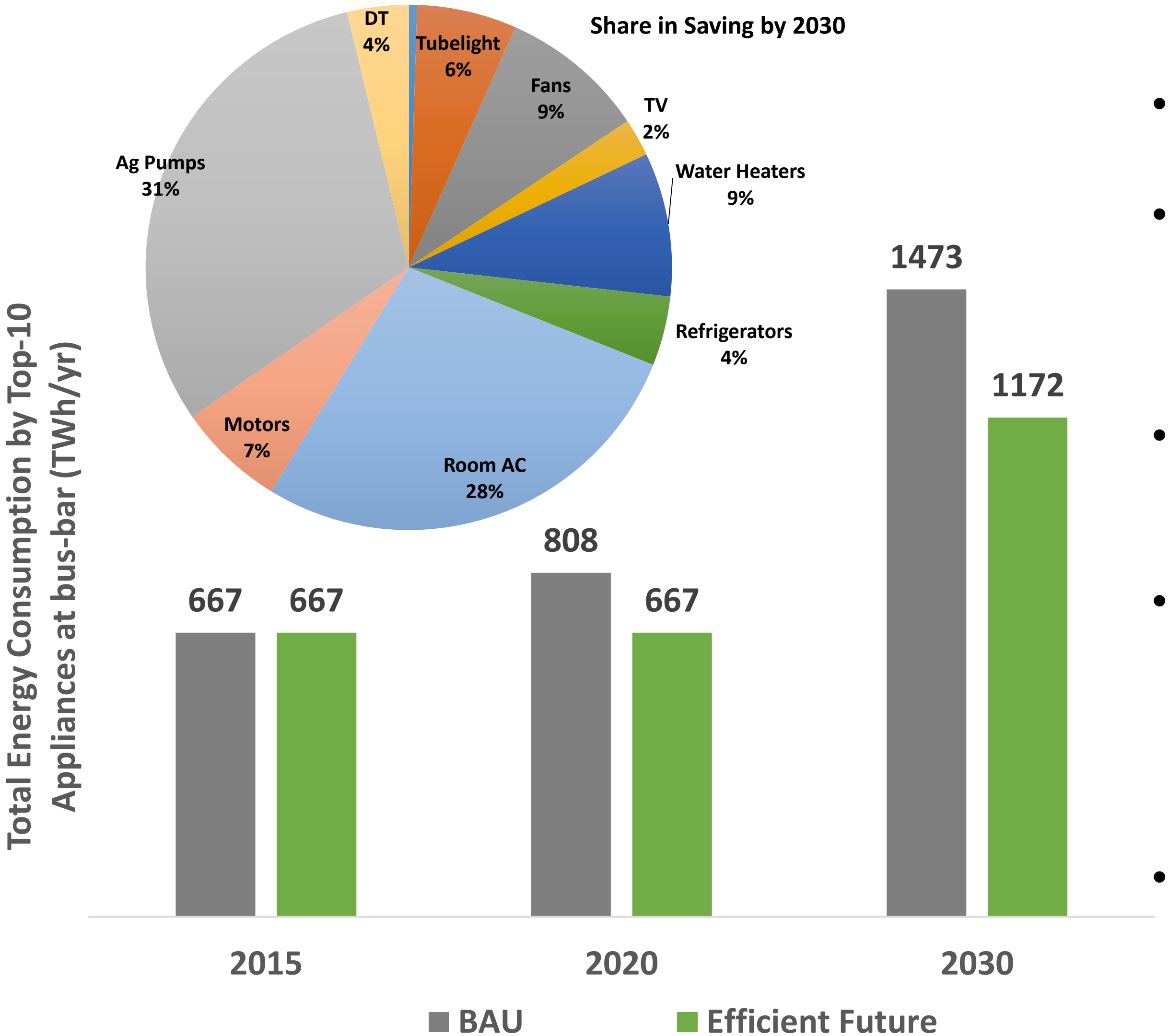
Energy consumption from top-10 appliances will more than double between 2015 and 2030 (BAU)





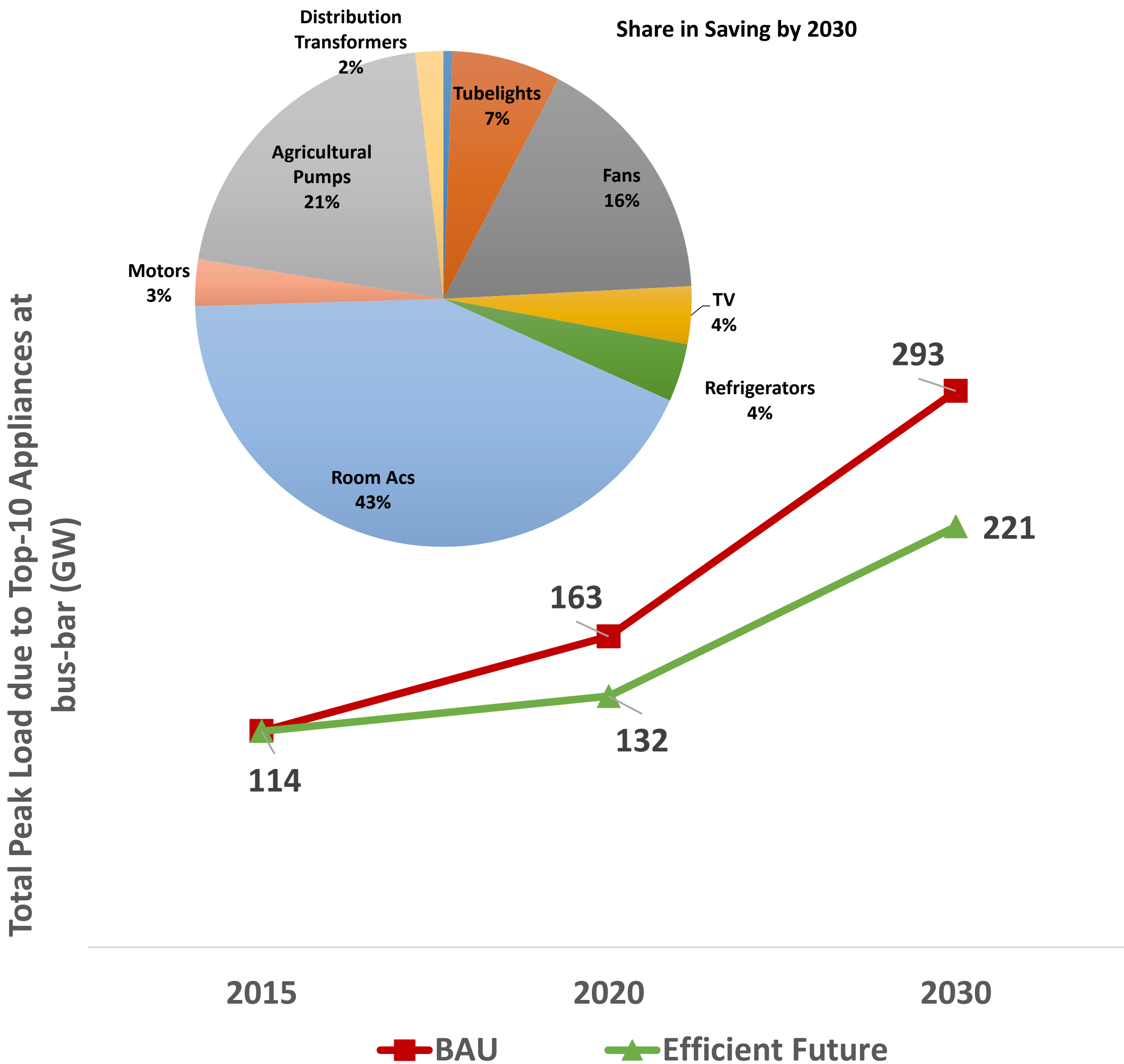
- The growth is driven by rising incomes and sustained commercial / industrial growth
- ACs, Motors, and Ag Pumps together responsible for ~80% of the energy consumption
- Peak load (evening concurrent) is dominated by ACs, Ag Pumps, and fans

By 2030, over 300 TWh/yr could be saved cost-effectively



- Saving potential of ~300 TWh/yr by 2030
- (~40% of incremental consumption between 2015 and 2030)
- Avoided CO_2 emissions = 200 MT/yr
- AC, Fans, Water Heaters, and Ag Pump together generate ~80% of the savings
- This is equivalent to ~180GW of solar PV

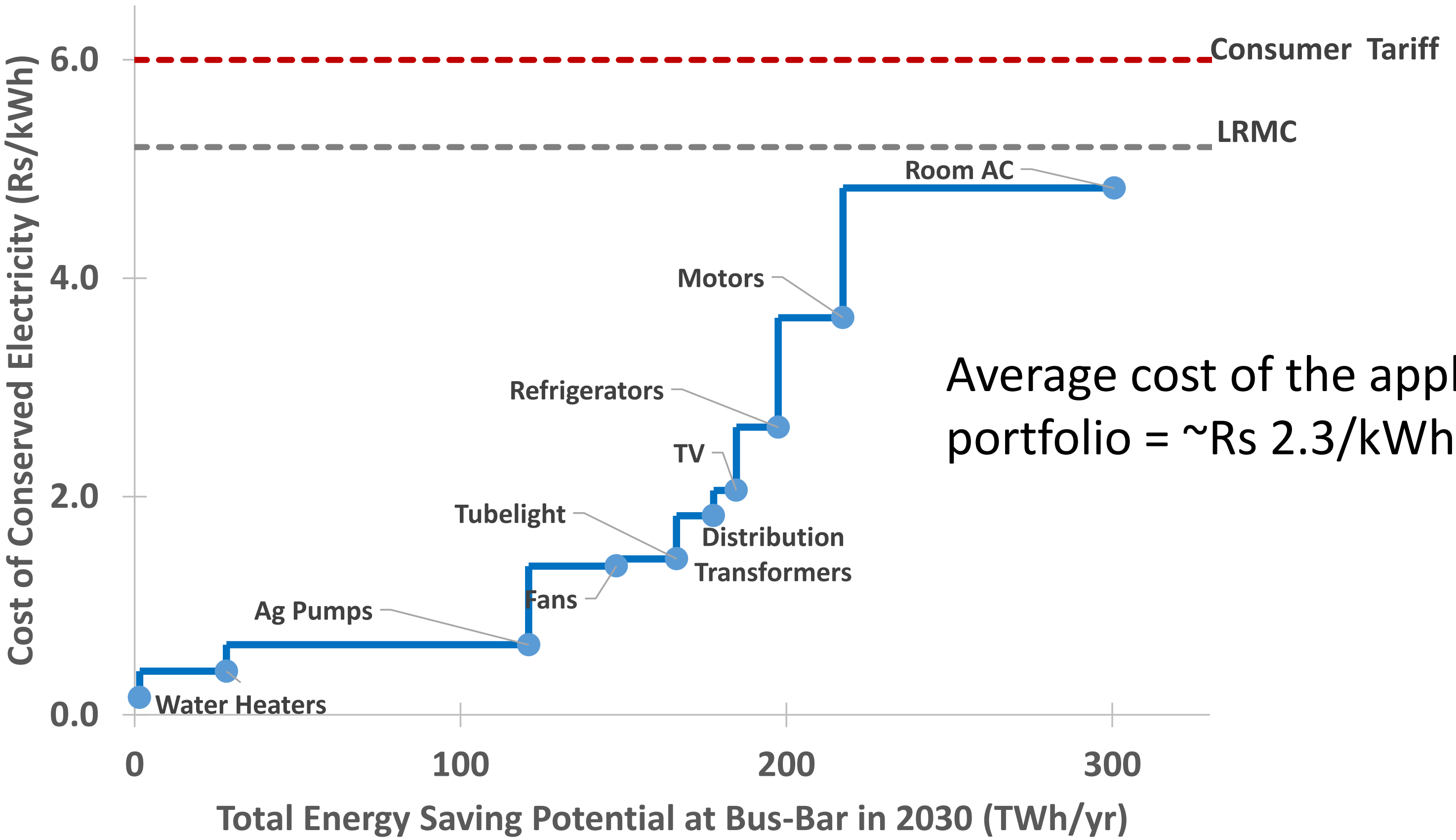
Appliance efficiency could save ~70GW of peak load



- 70GW peak saving implies avoiding ~150 new power plants of 500MW each
- AC, Fans, and Ag Pump together generate ~70% of the savings (50GW)
- Significant potential for making this demand "smart"

Entire energy saving potential is found to be cost-effective

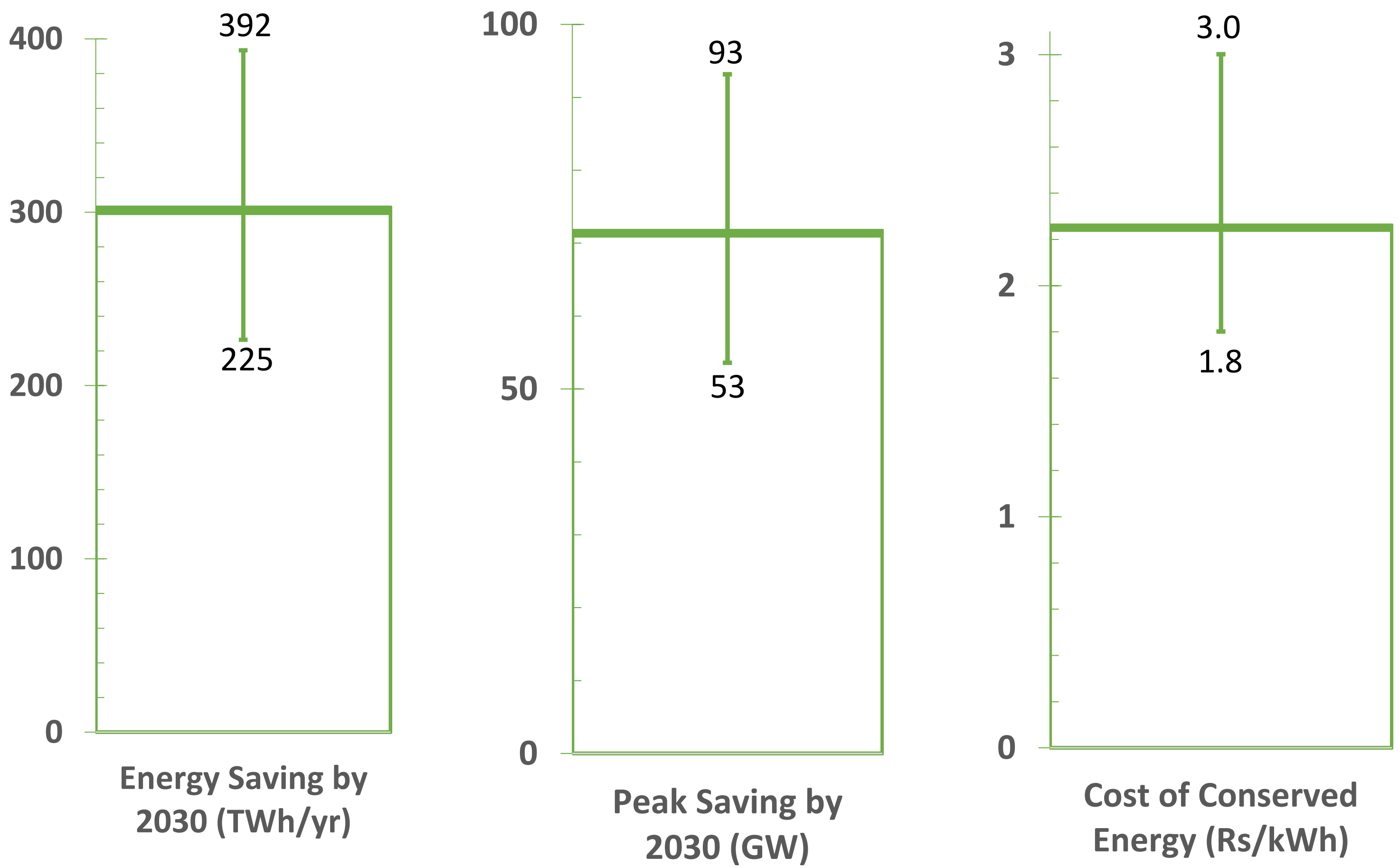
Cost of Conserved Energy (CCE) is less than the Long-Run Marginal Cost (LRMC) of energy for efficiency improvement in all appliances



Average cost of the appliance portfolio = ~Rs 2.3/kWh

Sensitivity Analysis

We conducted sensitivity analysis on appliance sales growth, hours of use, peak coincidence factors, and BAU efficiency improvement



Policies and programs for achieving this potential

- Coordinated push (standards) and pull (awards, labels, and incentives)
  - Widen and deepen the existing standards program
    - Cover more appliances, increase stringency, revise test procedures
  - Widen label bands to create product differentiation
  - Incentive (or other) programs can pull the top of the market
    - Ratepayer / third party funded or volume aggregation

- Set long term targets for ensuring industry support and compliance
  - E.g. Japan's top-runner program

- Complementary policies can create significant additional benefits
  - Smart (demand response ready) appliances can help RE grid integration
  - Improved buildings design can delay the appliance demand
  - Low-GWP refrigerants can double the overall GHG reduction benefits

Conclusion

- Growing appliance demand would have significant impact on the Indian power sector
  - Top-10 appliances will consume ~300GW by 2030 (~80% of system peak)
- There is significant cost-effective energy saving potential
  - 40% of the additional consumption could be saved cost-effectively
  - Saving of ~300 TWh/yr and 70GW of peak load by 2030
- Coordinated market push, pull, and complementary policies are needed

Thank You

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Supplementary material

Current status of appliance efficiency, expected improvements, and globally best available technology

Appliance	What is current status and expected improvements ?	What is the Best Available Technology (BAT)?
Lamps	Incandescent / CFL moving to LED (~120 lumens/W)	LED (~120 lumes/W)
FTLs	T-8, moving to LED	LED (~120 lumes/W)
Fans	Single phase induction motor; no major change (voluntary labels)	BLDC fan with efficient blade design
TV	Old stock is CRT; new sales LCD/LED	LED backlit w/ reflective polarizer & dimming
Water Heaters	Electric geysers	Natural Gas/LPG water heaters

Current status of appliance efficiency, expected improvements, and globally best available technology

Appliance	What is the current status and expected improvements ?	What is the Best Available Technology (BAT)?
Refrigerators	BAU efficiency improving rapidly due to MEPS revision	Thicker insulation, VIPs, efficient compressor, gasket
AC	Old stock is fixed speed; moving toward inverter ACs	Inverter AC with efficient components (compressor, HE, expansion valves)
Motors	IE 1 or IE 2 motors; No major change (voluntary labels)	IE 3++ (or IE5) motors
AG Pumps	Mono-block / submersible pumps; No major change (voluntary labels)	Brushless DC pump and efficient piping system
Distribution Transformers	Standard components; No major change	Reduction in losses with better material and cooling

How much efficiency improvement is possible with BAT?

Appliance	2016 BAU (kWh/yr)	2030 BAU (kWh/yr)	2016 BAT (kWh/yr)	BAT Incremental Cost (Rs)
Lamps	72	10	9	40
FTLs	95	44	16	50
Fans	120	120	48	840
TV	83	39	33	540
Water Heaters	240	146	-	500
Refrigerators	399	69	60	4,652
AC	1,992	1,269	797	54,401
Motors	9,196	9,196	8,910	7,000
AG Pumps	5,914	5,914	3,593	10,000
Distribution Transformers	2,186	2,186	905	20,000